

# The Magnetic Structure of GdAgSb<sub>2</sub>: XRES Study

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We report on a recent resonant magnetic x-ray scattering study aimed at determining the magnetic structure of GdAgSb<sub>2</sub>. In this case, the principle advantage of magnetic x-ray scattering arises from the fact that the naturally abundant Gd element is strongly neutron absorbing.

Single crystals of GdAgSb<sub>2</sub> were grown using a high temperature flux technique at the Ames Laboratory. Resonant magnetic x-ray scattering experiments were carried out on the 6-ID undulator beamline at the Advanced Photon Source. Polarization analysis of the scattered beam was performed using a pyrolytic graphite (PG) analyzer. Briefly stated, when used in the horizontal scattering geometry at the Gd L<sub>III</sub> edge energy, the PG(006) reflection effectively suppresses the charge scattering that is  $\sigma$ -polarized while passing the resonant and nonresonant scattering that is  $\pi$ -polarized.

GdAgSb<sub>2</sub> crystallizes in the tetragonal ZrCuSi<sub>2</sub>-type structure (space group P4/nmm) with Gd at the 2c positions. The sample was mounted with the (h0l)-zone in the scattering plane. The polarization of the incident beam, mostly s-polarized, is then parallel to (0k0)-direction. In this configuration, for resonant scattering that arises from dipole transitions, we are sensitive to that component of the magnetic moment in the scattering plane. No resonant scattering was observed in this geometry. However, after changing the analyzer to make use of the PG (002) reflection, allowing both s to s and p scattering to pass, magnetic peaks were observed at positions corresponding to  $t = (1/2\ 0\ 0)$ . The temperature dependence of the magnetic signal is shown in Fig. 1. The Neel temperature of approximately 13K agrees well with bulk measurements. Energy scans through the Gd L<sub>III</sub> edge absorption edge showed a resonant feature, indicating that the signal arises from quadrupole resonant scattering in this case. In order to confirm this, q-dependent integrated intensity measurements were performed, and a comparison with the theoretical scattering cross section for a quadrupole resonance shows good agreement if we assume that the moment direction is out of the scattering plane along the [0 k 0] direction. Similar measurements were also carried out at the Gd L<sub>II</sub> edge, where the same indication of electric quadrupole resonant scattering was observed.

The principle result of this work is the *ab initio* determination of the magnetic structure of GdAgSb<sub>2</sub>. Below 13K, the moments order antiferromagnetically, doubling the unit cell along the *a*-direction (or equivalently in the tetragonal structure *b*-direction) basal plane, with the moments ordered transverse to this direction within the basal plane.

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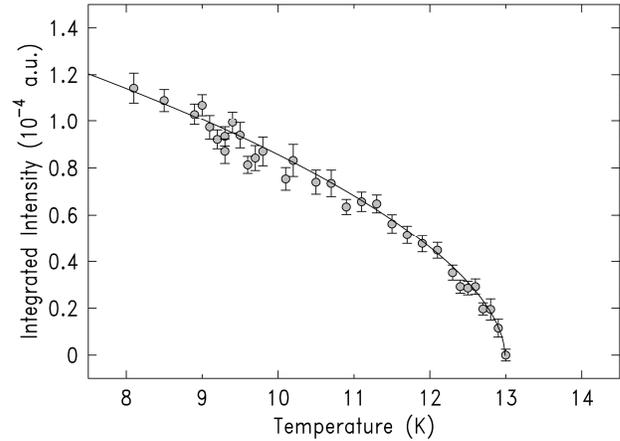


FIG. 1. Integrated intensity of (1/2 0 8) magnetic satellite.

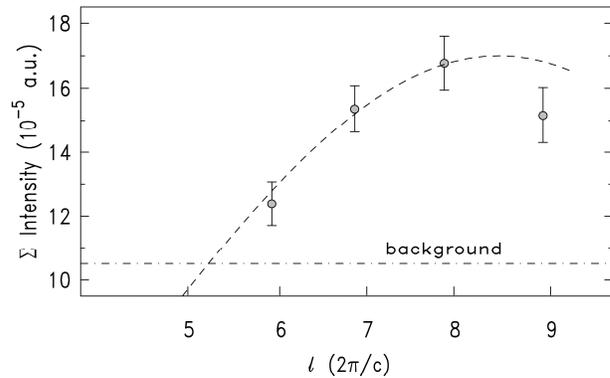


FIG. 2. Q-dependent integrated intensities of (1/2 0 l) magnetic satellites where dotted line is the calculated E2 cross section.

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